

1 WHAT IS CLAIMED IS:

1           1. An optical element comprising a substrate, a light  
2 reflection portion, and a support portion which supports  
3 said light reflection portion over said substrate;  
4           each of said light reflection portion and said support  
5 portion being constructed of at least one film;  
6           said support portion having one end part fixed to said  
7 substrate and having the other end part joined with the film  
8 which constructs said light reflection portion, and bending  
9 from said one end part toward said other end part, thereby  
10 to support a principal plane of said film constructing said  
11 light reflection portion, non-parallelly to a principal  
12 plane of said substrate.

1           2. An optical element as defined in claim 1, wherein  
2 said support portion supports the principal plane of said  
3 film constructing said light reflection portion,  
4 perpendicularly to the principal plane of said substrate.

1           3. An optical element as defined in claim 1, wherein  
2 said support portion is constructed of a multilayer film  
3 in which at least two films having different coefficients  
4 of thermal expansion are stacked.

1           4. An optical element as defined in claim 1, further

2 comprising a holding portion which keeps constant an angle  
3 between the principal plane of said film constructing said  
4 light reflection portion and the principal plane of said  
5 substrate.

1 5. An optical element as defined in claim 4, wherein:  
2 said holding portion is an angle holding portion which  
3 is interposed between said light reflection portion and said  
4 substrate; and  
5 said angle holding portion includes a film which has  
6 one end part fixed to said substrate, and which bends from  
7 said one end part toward the other end part.

1 6. An optical element as defined in claim 5, wherein  
2 said angle holding portion lies in touch with either said  
3 light reflection portion or said support portion, and it  
4 includes positional shift prevention means for preventing  
5 a relative positional shift between said angle holding  
6 portion and said light reflection portion or said support  
7 portion, at the touch part of said light reflection portion  
8 or said support portion.

1 7. An optical element as defined in claim 6, wherein  
2 said positional shift prevention means is a groovy structure  
3 which is formed in said light reflection portion or said  
4 support portion.

1           8. An optical element as defined in claim 5, wherein  
2 a film surface of said film of said angle holding portion  
3 is perpendicular to said principal plane of said light  
4 reflection portion, and a side surface of said film of said  
5 angle holding portion lies in touch with said light reflection  
6 portion.

1           9. An optical element as defined in claim 5, wherein  
2 at least one such angle holding portion is arranged on each  
3 of both sides of said principal plane of said light reflection  
4 portion.

1           10. An optical element as defined in claim 5, wherein:  
2 a sense of the bending of said film of said angle holding  
3 portion is reverse to a sense of the bending of said film  
4 constructing said support portion; and

5 a second light reflection portion is joined to said  
6 other end part of said film of said angle holding portion,  
7 and it is placed on said light reflection portion.

1           11. An optical element as defined in claim 1, wherein  
2 said light reflection portion is suspended from said other  
3 end of the bent film of said support portion toward said  
4 substrate.

1           12. An optical element as defined in claim 4, wherein

2 said holding portion is a thin-film multilevel structure  
3 which lies in touch with part of a member constituting said  
4 light reflection portion, said thin-film multilevel  
5 structure has a plurality of unit structural members which  
6 are successively stacked on said substrate, said each unit  
7 structural member includes a support part and a flat part  
8 supported by said support part, said support part and said  
9 flat part are unitarily constructed of a continuous thin  
10 film, and the stacked unit structural members have the thin  
11 films secured to each other at parts where they touch each  
12 other.

1 13. An optical element as defined in claim 12, wherein  
2 said thin-film multilevel structure lies in touch with either  
3 said light reflection portion or said support portion, and  
4 it includes positional shift prevention means for preventing  
5 a relative positional shift between said thin-film  
6 multilevel structure and said light reflection portion or  
7 said support portion, at the touch part of said light  
8 reflection portion or said support portion.

1 14. An optical element as defined in claim 13, wherein  
2 said positional shift prevention means is a groovy structure  
3 which is formed in said light reflection portion or said  
4 support portion.

1           15. An optical element comprising a substrate, a light  
2 reflection portion, and a support portion which supports  
3 said light reflection portion over said substrate;  
4           each of said light reflection portion and said support  
5 portion being constructed of at least one film;  
6           said support portion including at least two coupled  
7 members, a first member of which has one end part fixed to  
8 said substrate and has the other end part joined through  
9 the other member with the film constructing said light  
10 reflection portion, and bends from said one end part toward  
11 said other end part, thereby to support a principal plane  
12 of said film constructing said light reflection portion,  
13 non-parallelly to a principal plane of said substrate.

1           16. An optical element as defined in claim 15, wherein  
2 said support portion includes the second member which serves  
3 to couple said first member and said film constructing said  
4 light reflection portion, said second member is a bent film,  
5 and a sense of the bending of said second member is reverse  
6 to a sense of the bending of said first member.

1           17. An optical element as defined in claim 1, wherein  
2 said film constructing said light reflection portion is  
3 formed with a stepped structure at its peripheral edge part.

1           18. An optical element as defined in claim 1, further

2 comprising a temperature regulation portion for regulating  
3 a temperature of said support portion.

1 19. An optical element as defined in claim 1, wherein  
2 said light reflection portion employs as its light reflection  
3 surface, a surface of said film constructing said light  
4 reflection portion as has been on a side of said substrate  
5 during film formation.

1 20. A thin film structure comprising a substrate, a  
2 flat plate, and a support portion which supports said flat  
3 plate over said substrate;

4 said support portion being constructed of at least one  
5 film;

6 said support portion having one end part fixed to said  
7 substrate and having the other end part joined with said  
8 flat plate, and bending from said one end part toward said  
9 other end part, thereby to support a principal plane of said  
10 flat plate non-parallelly to a principal plane of said  
11 substrate.

1 21. A thin film structure comprising a substrate, a  
2 flat plate, and a support portion which supports said flat  
3 plate over said substrate;

4 said support portion including at least two coupled  
5 members, a first member of which has one end part fixed to

6 said substrate and has the other end part joined with said  
7 flat plate through the other member, and bends from said  
8 one end part toward said other end part, thereby to support  
9 a principal plane of said flat plate non-parallelly to a  
10 principal plane of said substrate.

1 22. An optical switch comprising a mirror portion,  
2 and a movable portion on which said mirror portion is mounted;  
3 said mirror portion including a light reflection  
4 portion, and a support portion which supports said light  
5 reflection portion over said movable portion;  
6 each of said light reflection portion and said support  
7 portion being constructed of at least one film;  
8 said support portion having one end part fixed to said  
9 movable portion and having the other end part joined with  
10 the film which constructs said light reflection portion,  
11 and bending from said one end part toward said other end  
12 part, thereby to support a principal plane of said film  
13 constructing said light reflection portion, non-parallelly  
14 to a principal plane of said movable portion.

1 23. An optical switch comprising a mirror portion,  
2 and a movable portion on which said mirror portion is mounted;  
3 said mirror portion including a light reflection  
4 portion, and a support portion which supports said light  
5 reflection portion over said movable portion;

6        said light reflection portion being constructed of a  
7 film;

8        said support portion including at least two coupled  
9 members, a first member of which has one end part fixed to  
10 said movable portion and has the other end part joined through  
11 the other member with said film constructing said light  
12 reflection portion, and bends from said one end part toward  
13 said other end part, thereby to support a principal plane  
14 of said film constructing said light reflection portion,  
15 non-parallelly to a principal plane of said movable portion.

1        24. A method of manufacturing an optical element,  
2 comprising:

3        the step of forming a sacrificial layer which has an  
4 opening, on a substrate;

5        the step of forming a support film of predetermined  
6 shape on that position of said sacrificial film which includes  
7 said opening, and forming a light reflection film on that  
8 position of said sacrificial film which is joined with one  
9 end part of said support film; and

10       the step of removing said sacrificial film, whereby  
11 said support film is bent by an internal stress of said support  
12 film so as to support a principal plane of said light  
13 reflection film non-parallelly to a principal plane of said  
14 substrate.



1           25. A method of manufacturing an optical element as  
2 defined in claim 24, wherein said sacrificial layer is formed  
3 of a resist.

1           26. A method of manufacturing an optical element as  
2 defined in claim 24, wherein said support film is formed  
3 of a stacked structure of at least two layers made of materials  
4 of different coefficients of thermal expansion.

1           27. An optical switch comprising a mirror portion  
2 which includes a light reflection member, a movable portion  
3 on which said mirror portion is mounted, and a holding portion  
4 which lies in touch with part of a member constituting said  
5 mirror portion, in order to keep an angle of said light  
6 reflection member;

7           said holding portion being a thin-film multilevel  
8 structure;

9           said thin-film multilevel structure having a plurality  
10 of unit structural members which are successively stacked  
11 on said movable portion;

12          said each unit structural member including a support  
13 part and a flat part supported by said support part, said  
14 support part and said flat part being unitarily constructed  
15 of a continuous thin film;

16          the stacked unit structural members having the thin  
17 films secured to each other at parts where they touch each

18 other.

1           28. An optical switch as defined in claim 27, wherein  
2 said thin-film multilevel structure lies in touch with either  
3 said light reflection portion or said support portion, and  
4 it includes positional shift prevention means for preventing  
5 a relative shift between said thin-film multilevel structure  
6 and said light reflection portion or said support portion,  
7 at the touch part of said light reflection portion or said  
8 support portion.

1           29. An optical switch as defined in claim 28, wherein  
2 said positional shift prevention means is a groovy structure  
3 which is formed in said light reflection portion or said  
4 support portion.

1           30. An optical switch as defined in claim 27, wherein:  
2           said mirror portion includes a support portion in order  
3 to support said light reflection member over said movable  
4 portion; and  
5           said support portion includes at least two coupled  
6 members, a first member of which has one end part fixed to  
7 said movable portion and has the other end part joined with  
8 said light reflection member through the other member, and  
9 bends from said one end part toward said other end part,  
10 thereby to support said light reflection member

11 non-parallelly to a principal plane of said movable portion.

1           31. An optical switch as defined in claim 27, wherein  
2 said thin film constructing said each unit structural member  
3 is formed with a stepped structure at its peripheral edge.

1           32. An optical switch as defined in claim 27, wherein  
2 said support part of the unit structural member located at  
3 an upper stage is mounted on said flat part of the unit  
4 structural member at an immediately lower stage.

1           33. An optical switch as defined in claim 32, wherein  
2 in the stacked unit structural members, said unit structural  
3 member located at the upper stage is smaller in the number  
4 of the support parts.

1           34. An optical switch as defined in claim 27, wherein  
2 in said plurality of unit structural members, the unit  
3 structural member of lowermost stage is constructed  
4 unitarily with said movable portion.

1           35. An optical switch as defined in claim 27, wherein  
2 at least one of said plurality of unit structural members  
3 is constructed by patterning the same thin film as a thin  
4 film which forms said member constituting said mirror  
5 portion.

1           36. An optical switch as defined in claim 27, wherein  
2 said thin film constructing said each unit structural member  
3 is a triple-layer film, in which a film of uppermost layer  
4 and a film of lowermost layer are of the same material.

1           37. An optical switch comprising a mirror portion  
2 which includes a light reflection member, a movable portion  
3 on which said mirror portion is mounted, and a holding portion  
4 which lies in touch with part of a member constituting said  
5 mirror portion, in order to keep an angle of said light  
6 reflection member;

7           said holding portion being a thin-film multilevel  
8 structure;

9           said thin-film multilevel structure having a plurality  
10 of unit structural members which are successively stacked  
11 on said movable portion;

12          said each unit structural member including a support  
13 part which has a hollow opening, a flat part which covers  
14 said opening, and a filling material with which said hollow  
15 opening of said support portion is filled up, each of said  
16 support part and said flat part being formed of a thin film;

17          the stacked unit structural members being such that  
18 said support part of the unit structural member located at  
19 an upper stage is mounted on said flat part of the unit  
20 structural member at an immediately lower stage.

1           38. An optical switch as defined in claim 37, wherein  
2 said thin-film multilevel structure lies in touch with either  
3 said light reflection portion or said support portion, and  
4 it includes positional shift prevention means for preventing  
5 a relative shift between said thin-film multilevel structure  
6 and said light reflection portion or said support portion,  
7 at the touch part of said light reflection portion or said  
8 support portion.

1           39. An optical switch as defined in claim 38, wherein  
2 said positional shift prevention means is a groovy structure  
3 which is formed in said light reflection portion or said  
4 support portion.

1           40. An optical switch as defined in claim 37, wherein  
2 said thin film which constructs said support part of the  
3 unit structural member located at an upper stage, and said  
4 thin film which constructs said flat part of the unit  
5 structural member at a lower stage for mounting said support  
6 part are secured to each other.

1           41. An optical switch comprising a substrate, a  
2 movable portion one end part of which is fixed to said  
3 substrate, and a mirror portion which is mounted on a side  
4 of the other end part of said movable portion;  
5           said movable portion being constructed of at least two

6 films, and being bent by internal stresses of said at least  
7 two films, thereby to raise the other end part bearing said  
8 mirror portion, over said substrate;

9       said mirror portion including a light reflection member  
10 which is mounted on said movable portion so that a light  
11 reflection surface may be directed perpendicularly to a  
12 principal plane of said substrate;

13       said light reflection member being inclinedly mounted  
14 on said movable portion so that its upper end edge may become  
15 parallel to said substrate in a state where said movable  
16 portion has raised said mirror portion.

1       42. An optical element comprising a substrate, an  
2 optical film which has a desired optical characteristic,  
3 and a support portion which supports said optical film over  
4 said substrate;

5       said support portion being constructed of at least one  
6 film;

7       said support portion having one end part fixed to said  
8 substrate and having the other end part joined with a film  
9 constructing said optical film, directly or through another  
10 member, and bending from said one end part toward said other  
11 end part, thereby to support a principal plane of said film  
12 constructing said optical film, non-parallelly to a  
13 principal plane of said substrate.

1           43. An optical device comprising an optical element,  
2 a movable portion on which said optical element is mounted,  
3 and a substrate which holds said movable portion;  
4           said movable portion being made of at least one film,  
5 having one end part fixed to said substrate and having said  
6 optical element mounted on a side of the other end part,  
7 at least a part near the fixed end part being formed of a  
8 stacked structure in which at least two films are stacked,  
9 said stacked structure being bent by an internal stress,  
10 thereby to support said other end part at a position remote  
11 from said substrate;  
12           said movable portion being formed with a stepped  
13 structure along a peripheral edge of its part bearing said  
14 optical element.

1           44. An optical device as defined in claim 43, wherein  
2 in order to form said stepped structure, said movable portion  
3 is formed with a convex portion along the peripheral edge  
4 of its part bearing said optical element.

1           45. An optical device comprising an optical element,  
2 a movable portion on which said optical element is mounted,  
3 and a substrate which holds said movable portion;  
4           said movable portion being, at least partially, a  
5 stacked structure made of at least two films, having one  
6 end part fixed to said substrate and having said optical

7 element mounted on a side of the other end part, said stacked  
8 structure being bent by an internal stress, thereby to support  
9 said other end part at a position remote from said substrate;  
10 said stacked structure including a metal film, said  
11 metal film being patterned into a predetermined pattern,  
12 said pattern including an electrode pattern for an  
13 electrostatic force as acts as an electrode for driving said  
14 movable portion by the electrostatic force.

1 46. An optical device as defined in claim 45, wherein  
2 said pattern of said metal film further includes a current  
3 path pattern for a Lorentz force as acts as a current path  
4 for driving said movable portion by the Lorentz force.

1 47. An optical device as defined in claim 46, wherein  
2 said electrode pattern for said electrostatic force and said  
3 current path pattern for said Lorentz force are respectively  
4 connected to voltage applying wiring lines and current  
5 feeding wiring lines of said substrate through said one end  
6 part fixed to said substrate.

1 48. An optical device as defined in claim 43, wherein:  
2 said optical element includes an optical film which  
3 has a desired optical characteristic, and a support portion  
4 which supports said optical film over said movable portion;  
5 said support portion being constructed of at least one



6 film;

7       said support portion having one end part fixed to said  
8 substrate and having the other end part joined with a film  
9 constructing said optical film, directly or through another  
10 member, and bending from said one end part toward said other  
11 end part, thereby to support a principal plane of said film  
12 constructing said optical film, non-parallelly to a  
13 principal plane of said substrate.

1       49. An optical device comprising a substrate, an  
2 optical element which is mounted on said substrate, and a  
3 suppression portion which serves to suppress a positional  
4 fluctuation of said optical element;

5       said optical element including an optical film which  
6 has a desired optical characteristic, and a support portion  
7 which supports said optical film, said support portion  
8 including a bent film member, said film member having one  
9 end part fixed to said substrate and having the other end  
10 part raised by said bent film member, thereby to support  
11 a principal plane of said optical film non-parallelly to  
12 a principal plane of said substrate;

13       said suppression portion suppressing a positional  
14 fluctuation of said optical film in a normal direction of  
15 said optical film or in an upward direction.

1       50. An optical device as defined in claim 49, wherein

2 said support portion includes not only said bent film member,  
3 but also a second bent film member, a joint portion, and  
4 an optical-film support portion on which said optical film  
5 is mounted;

6 said joint portion being joined to said other end part  
7 of the first-mentioned film member, said second film member  
8 having one end part joined to said joint portion and having  
9 said optical-film support portion joined to the other end  
10 part hanging down from said joint portion;

11 said suppression portion suppressing a positional  
12 fluctuation of said optical-film support portion in order  
13 to suppress the positional fluctuation of said optical film.

1 51. An optical device as defined in claim 50, wherein  
2 said suppression portion is a member which is formed by cutting  
3 and bending part of said substrate.

1 52. An optical device as defined in claim 50, wherein  
2 said suppression portion is a multistage multilevel  
3 structure which is formed by stacking multilevel structures  
4 constructed of thin films, a plurality of stages.

1 53. An optical device as defined in claim 52, wherein  
2 said multistage multilevel structure has a hook-shaped part,  
3 and said hook-shaped part is inserted into an opening provided  
4 in said optical-film support portion.

1           54. An optical device as defined in claim 52, wherein  
2 said multistage multilevel structure has an extension part  
3 which hangs over said optical-film support portion.

1           55. An optical device as defined in claim 50, wherein  
2 said suppression portion includes a protuberant part which  
3 is provided from said optical-film support portion toward  
4 said substrate, and an opening which is provided in said  
5 substrate, and said protuberant part is snugly fitted in  
6 said opening.

1           56. An optical device as defined in claim 49, wherein  
2 said substrate is a movable substrate for moving said optical  
3 element, and it is constructed of at least one film.